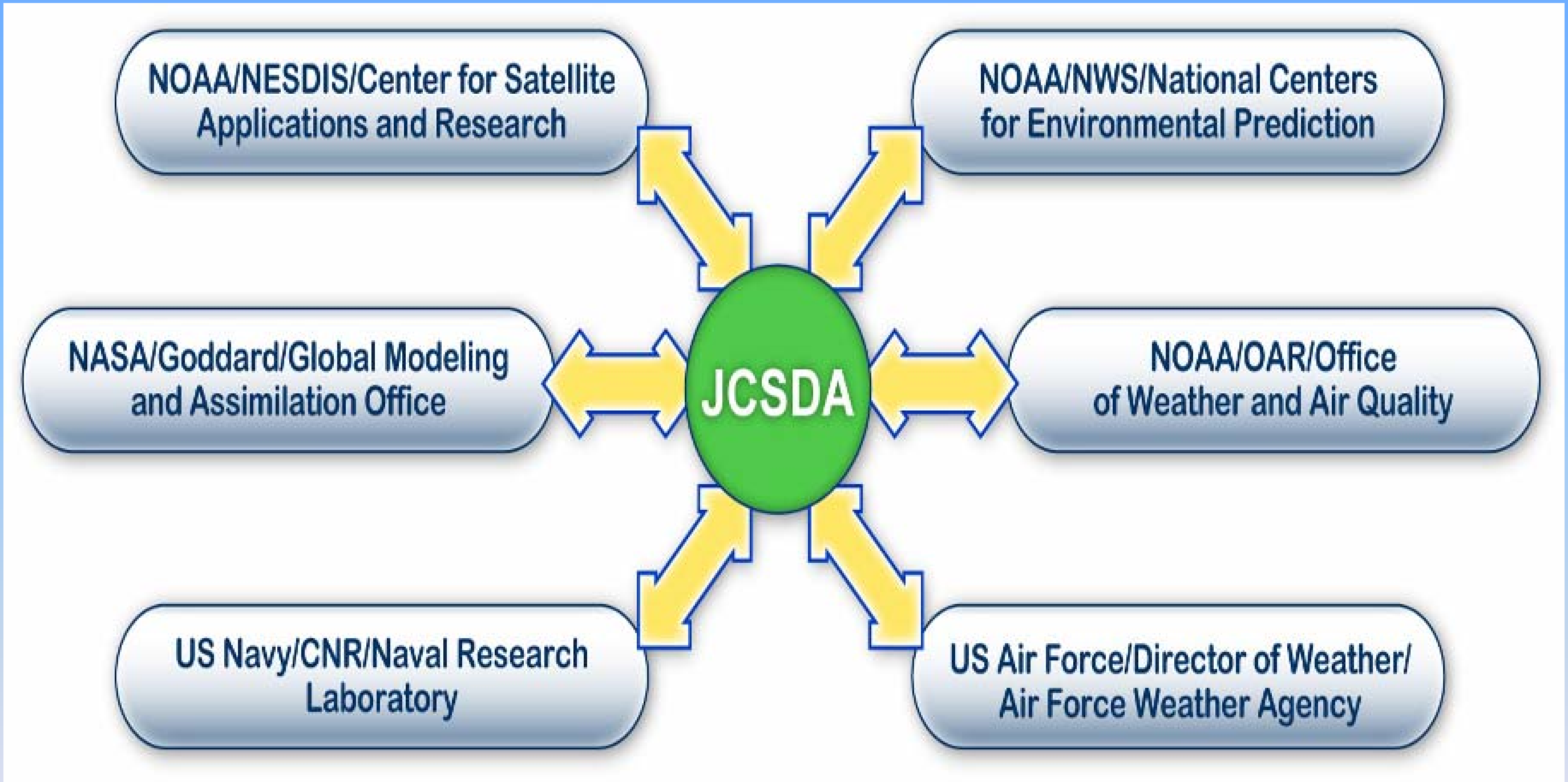
NESDIS Contributions to JCSDA Program

Dr. Fuzhong Weng
JCSDA Acting Executive Deputy Director

Overview

- **NESDIS/STAR Contributions**
  - JCSDA organizational developments
  - Science development and implementation
- **NESDIS/STAR Accomplishments**
  - CRTM version 1
  - AIRS full spectral/fovs
  - SSMIS cloudy radiance/UAS channels
  - COSMIC
  - Fire and Smoke
  - New NDVI
  - Peer Reviewed Publications
- **Scientific Challenges**

JCSDA Partners



In 2001 the Joint Center was established[2] by NASA and NOAA and in 2002, the JCSDA expanded its partnerships to include the U.S. Navy and Air Force weather agencies.

[2] *Joint Center for Satellite Data Assimilation: Luis Uccellini, Franco Einaudi, James F. W. Purdom, David Rogers: April 2000.*

NESDIS Supports to the JCSDA Organizational Developments

- **Provide annual funding of $3.3M thru NOAA base appropriation**
- **Leverage JCSDA program through GOES-R, POES, NDE, R2O and other Cal/Val programs**
- **Provide essential staffs for program planning, JCSDA newsletters, monthly/quarterly highlights, seminars, website, funding transfer, and travel orders**
- **Recruit 3 new FTEs and train more contractors to work closely with EMC on various data assimilation projects**
- **Provide centralized offices for visitors and contractors**
- **Manage the federal funding opportunity (FFO) proposal selection with NOAA grant program**
- **Provide timely access to POES/GOES/Metop operational satellite data**

NESDIS Supports to JCSDA Science Developments and Implementation

- Lead critical JCSDA science developments and implementation (JSDI) tasks
- JAS special volume on assimilation of cloud and precipitation data from satellites
- IEEE TGARS special volume on surface remote sensing and property modeling

STAR Leading JSDIs Related to JCSDA Science Priorities

JCSDA Community Radiative Transfer Model - Y, Han, F. Weng, Q. Liu, B. Yan, R. Vogal

Data Assimilation for AQ forecasts - S. Kondragunta, T. Beck, L. Flynn

Preparation for Early Access to Advanced Satellite Data - M. Goldberg, W. Wolf, and P. Chang

Satellite Data Products Needed for Model Initialization and Assimilation - D. Tarpley, L. Jiang, W. Guo

Perform Assessments of Impacts of Advanced Satellite Data - J. Jung, Q. Liu, L. Cucurull/J. Yoe

Calibration and Validation Support - F. Weng, B. Yan, C. Cao, F. Wu, T. Mo

Contributions to Education, Training, & Outreach - M. Goldberg, F.Weng, C. Barnet, R. Ferraro, T. Kleespies

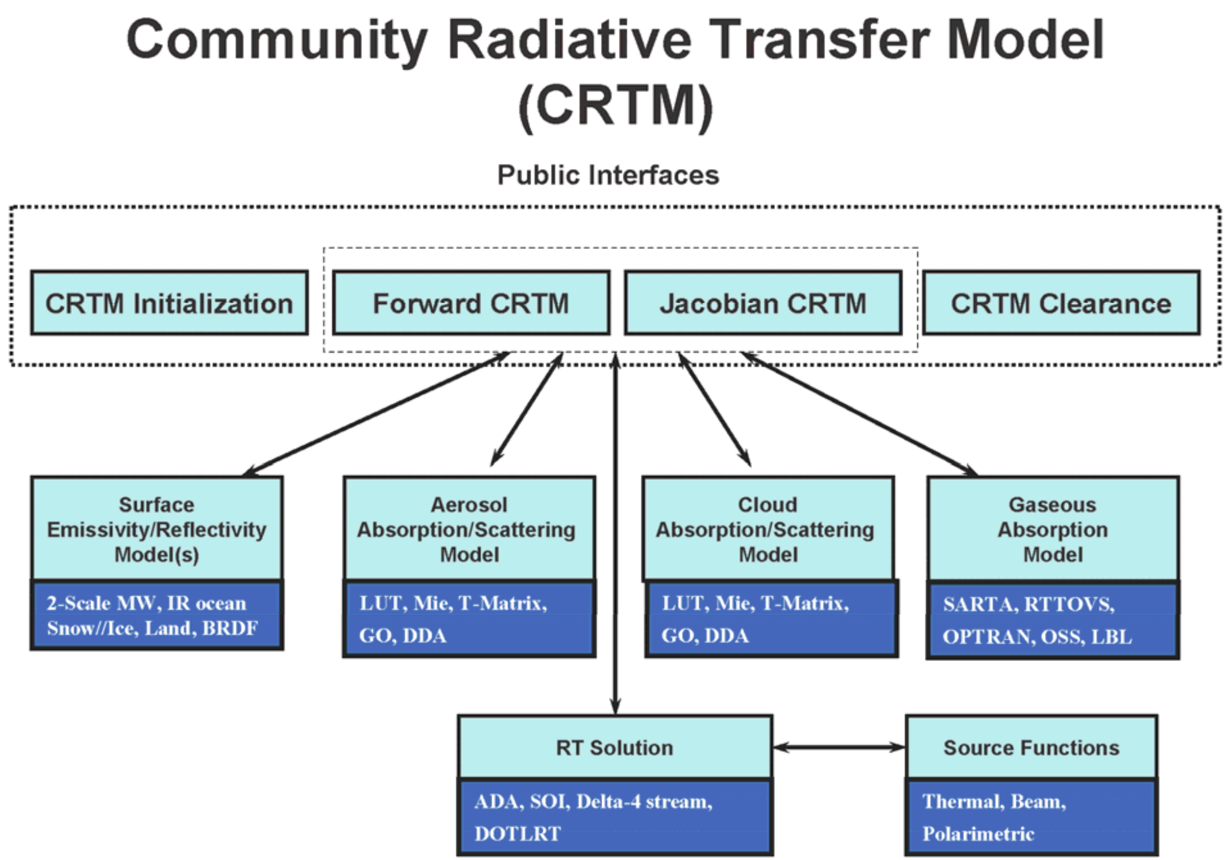
Development and Implementation of the Community Radiative Transfer Model (CRTM)

Y. Han, P. van Delst, Q. Liu, F. Weng, Y. Chen, D. Groff, B. Yan, N. Nalli, R. Treadon, J. Derber

CRTM Capability

Supported Instruments

- GOES-R ABI
- Metop IASI
- TIROS-N to NOAA-18 AVHRR
- TIROS-N to NOAA-18 HIRS
- GOES-8 to 13 Imager channels
- GOES-8 to 13 sounder channel 08-13
- Terra/Aqua MODIS Channel 1-10
- METEOSAT-SG1 SEVIRI
- Aqua AIRS
- Aqua AMSR-E
- Aqua AMSU-A
- Aqua HSB
- NOAA-15 to 18 AMSU-A
- NOAA-15 to 17 AMSU-B
- NOAA-18 MHS
- TIROS-N to NOAA-14 MSU
- DMSP F13 to15 SSM/I
- DMSP F13,15 SSM/T1
- DMSP F14,15 SSM/T2
- DMSP F16 SSMIS
- NPP ATMS
- Coriolis Windsat

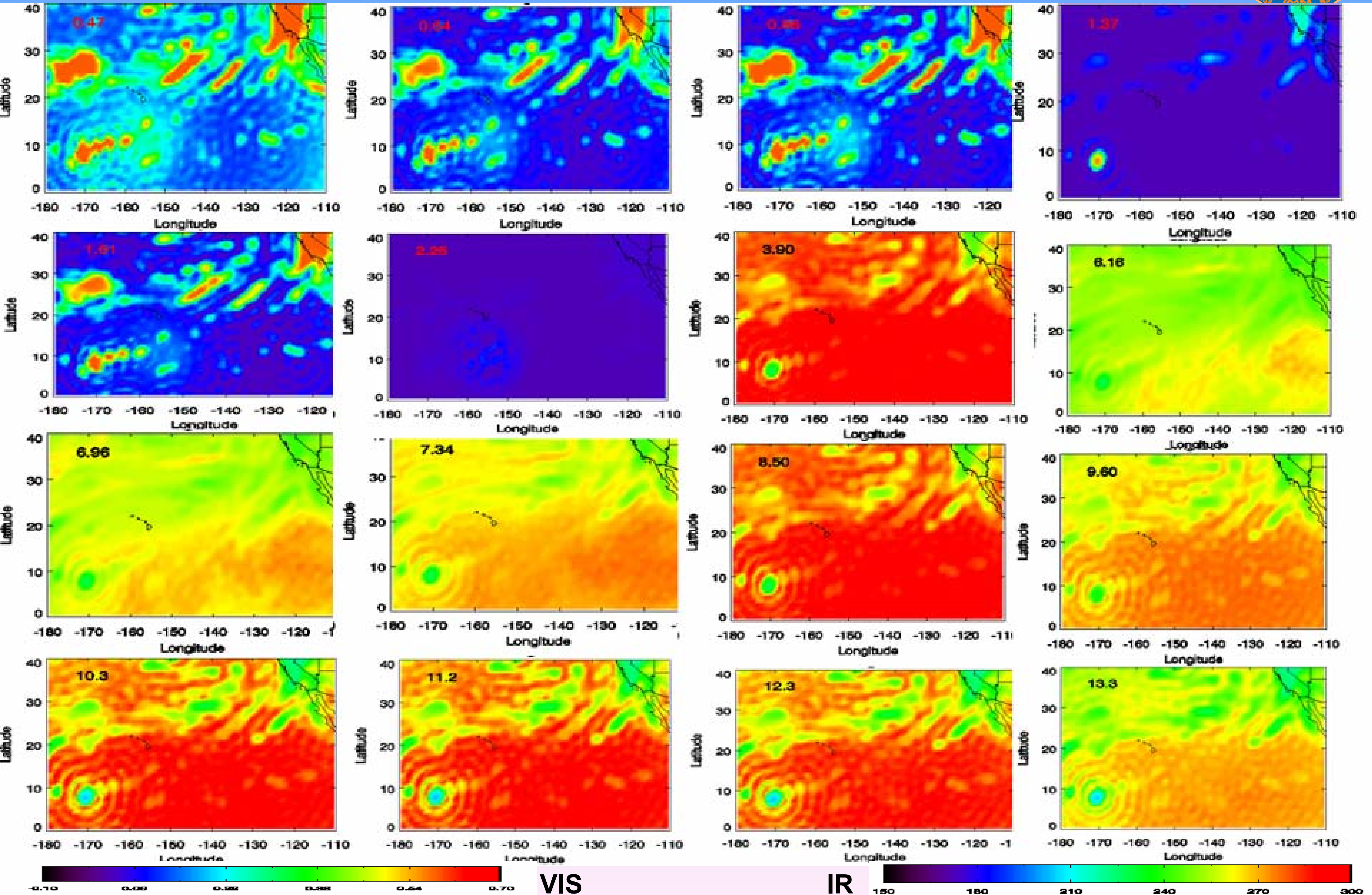


Significance: CRTM framework is designed to accelerate transition of new radiative transfer science for assimilation of operational and research satellite data in NWP models and to improve the retrieval technology in satellite remote sensing system

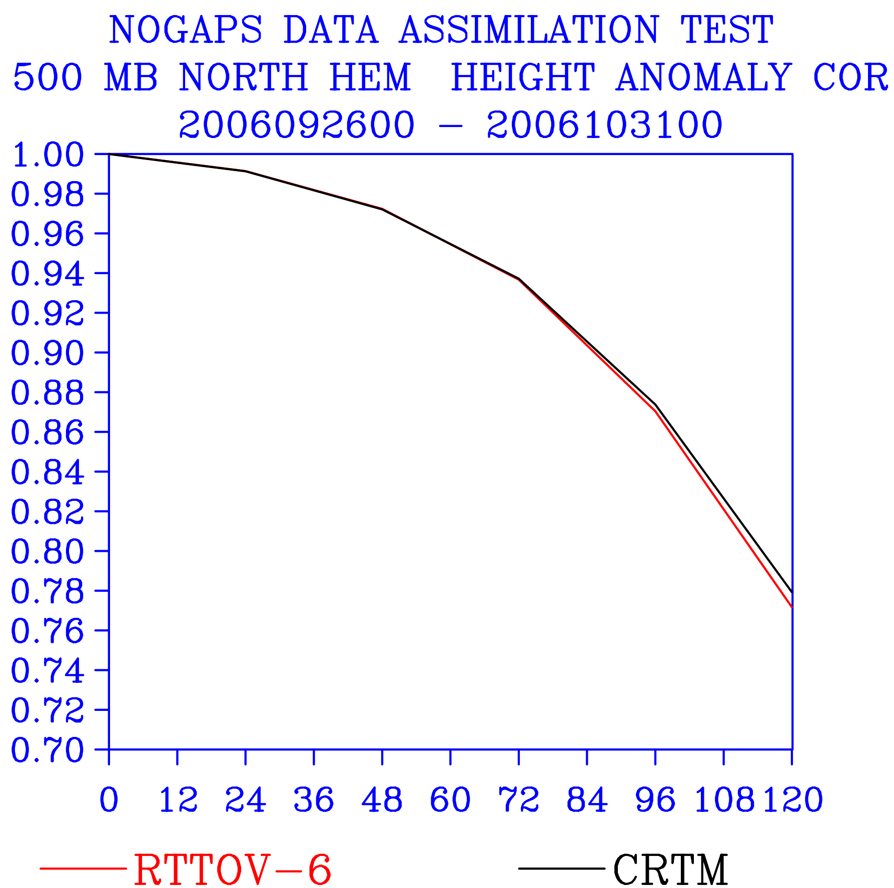
Major Progress

- CRTM has been integrated into the GSI at NCEP/EMC
- Version 1 of CRTM has been released to the public
- CRTM with OSS/SARTA/OPTRAN-V7
- CRTM with clouds and aerosol scattering

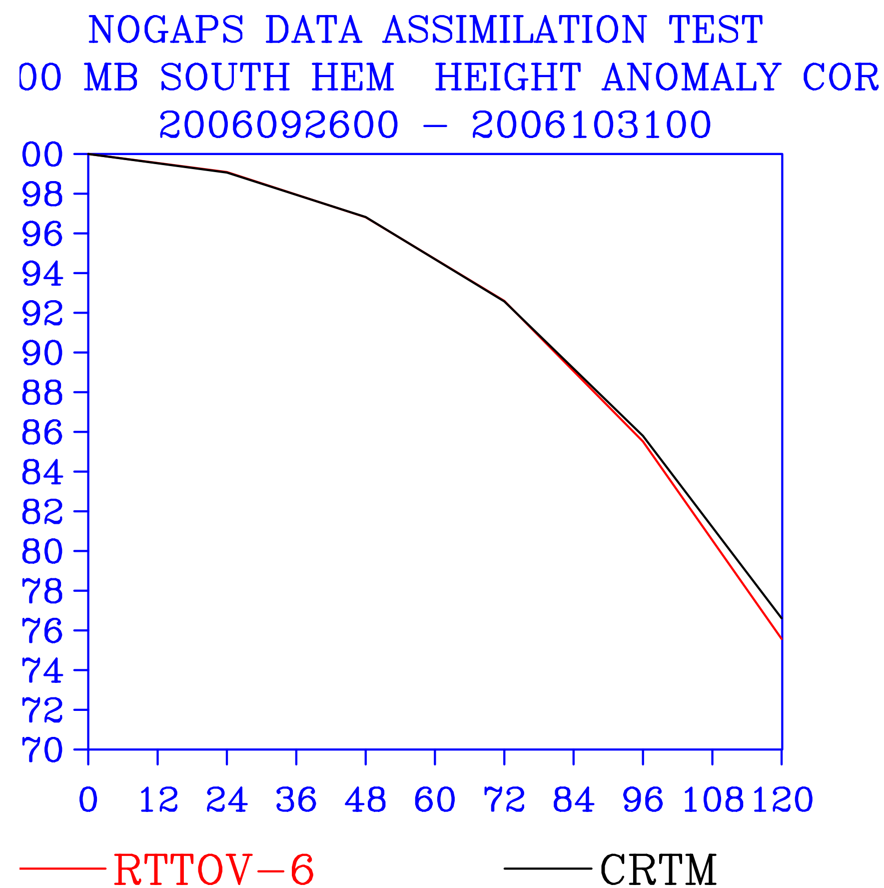
GOES-R ABI Simulations using CRTM



“CRTM” Impact
500 mb Height Anomaly Correlation (NRL NOGAPS)



Northern Hemisphere



Southern Hemisphere

September 26 - October 19, 2006

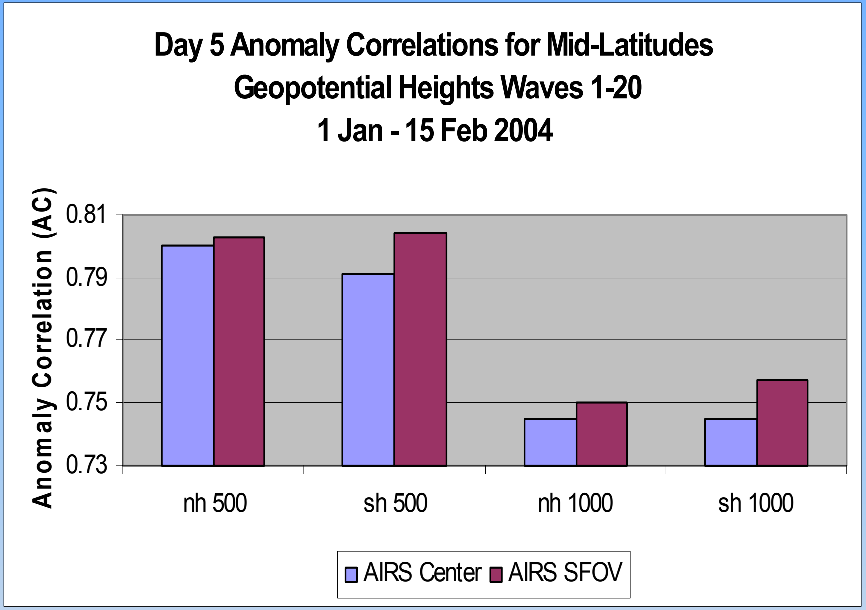
Preparation for Advanced Instruments: Some Recent Advances

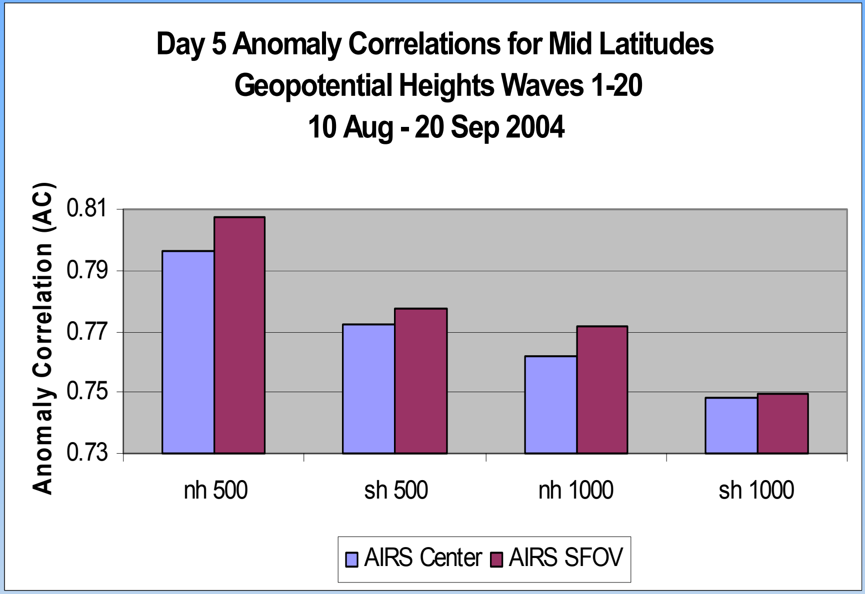
AIRS Data Usage per Six Hourly Analysis Cycle

Data Category	Number of AIRS Channels
Total Data Input to Analysis	~200×10^6 radiances (channels)
Data Selected for Possible Use	~2.1×10^6 radiances (channels)
Data Used in 3D VAR Analysis	~0.85×10^6 radiances (channels)
Data from all AIRS fovs	~6% more radiances
Data from full AIRS spectrum	

Jim Jung et al., 2007, JCSDA Science Workshop

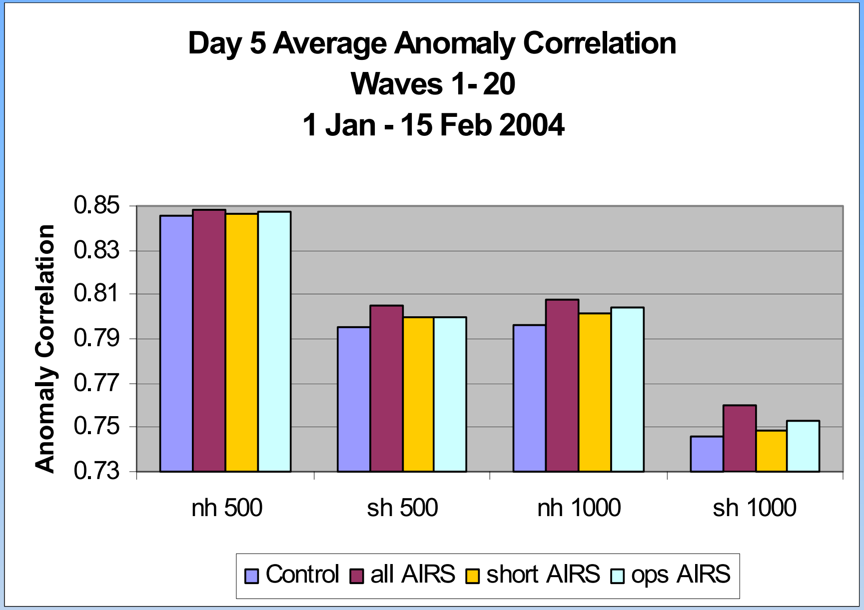
Full Spatial Resolution Experiment

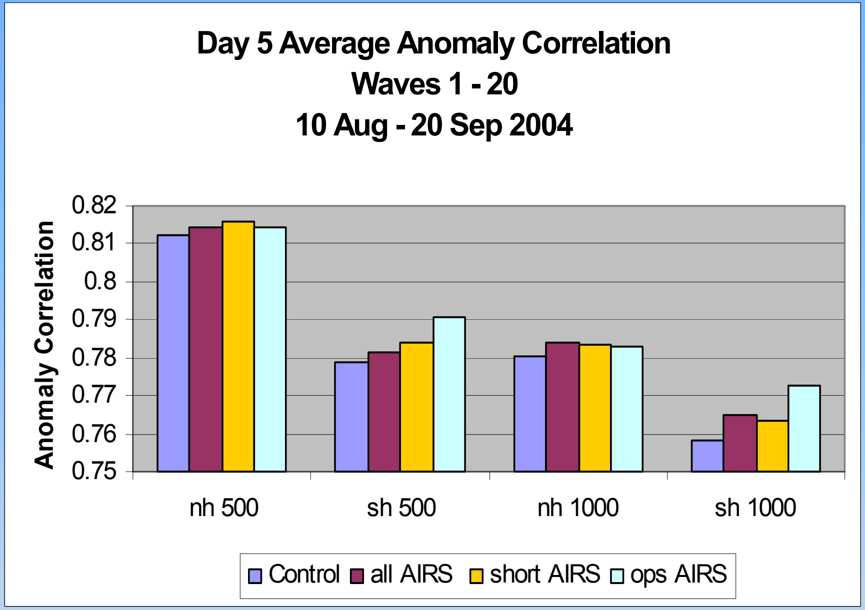




Day 5 Geopotential Height Anomaly Correlations for the GFS with AIRS 1 of 18 FOV (AIRS Center) and AIRS SFOV data (AIRS SFOV) at 1000 and 500 hPa for the Northern and Southern Hemispheres.

Full Spectral Resolution Experiment





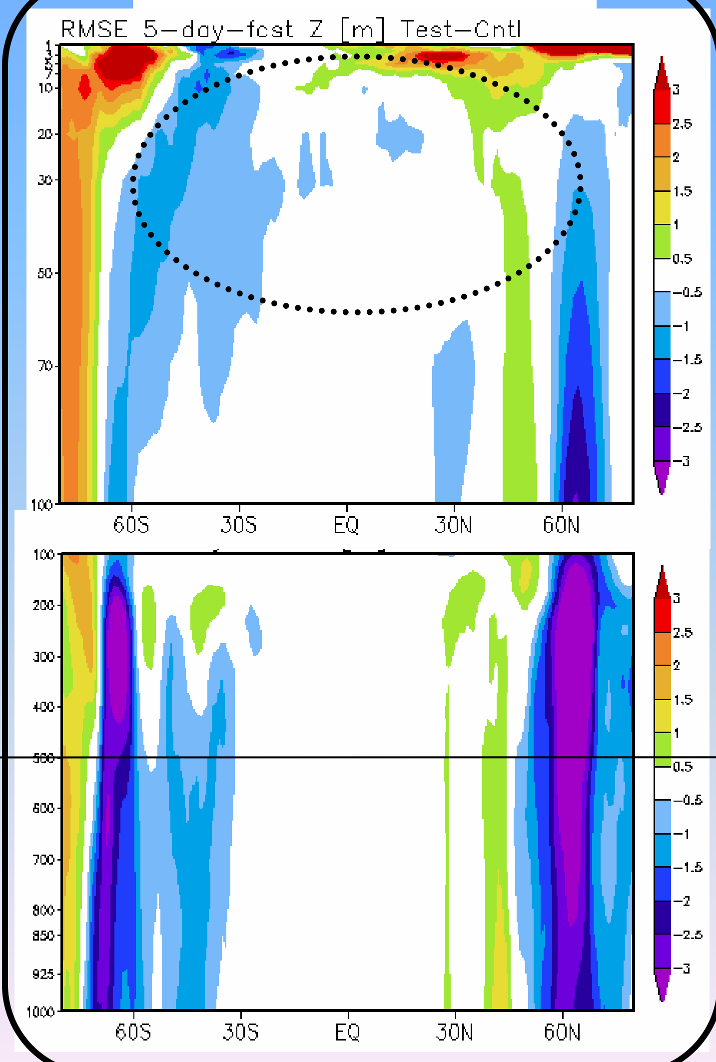
Day 5 Geopotential Height Anomaly Correlations for the GFS for AIRS denied (Control), 251 AIRS data (all AIRS), 115 AIRS water vapor and shortwave (short AIRS), and 152 AIRS data (ops AIRS) at 1000 and 500 hPa for the Northern and Southern Hemispheres.

Using SSMI, SSMIS, WindSat AMSR(E) data in Preparation for a Scanning Imager/Sounder

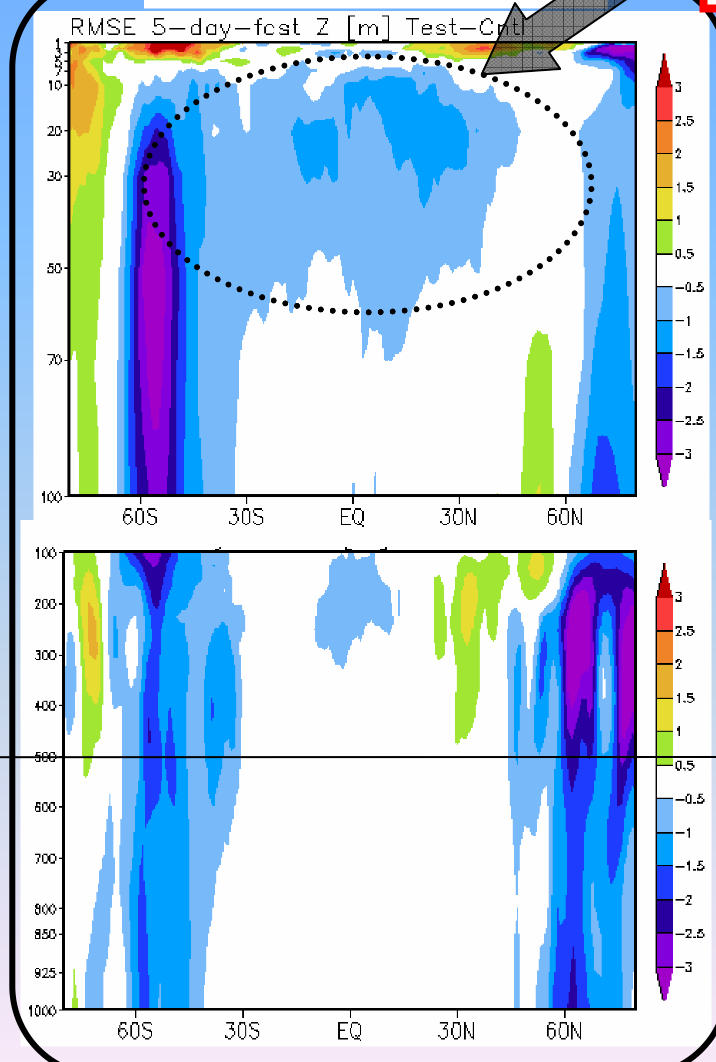
5day Z forecast zonal averaged RMSE difference (Test-Cntl)

Blue color means improvement.

UKMO SSMIS



NESDIS SSMIS



Much improvement in the stratosphere

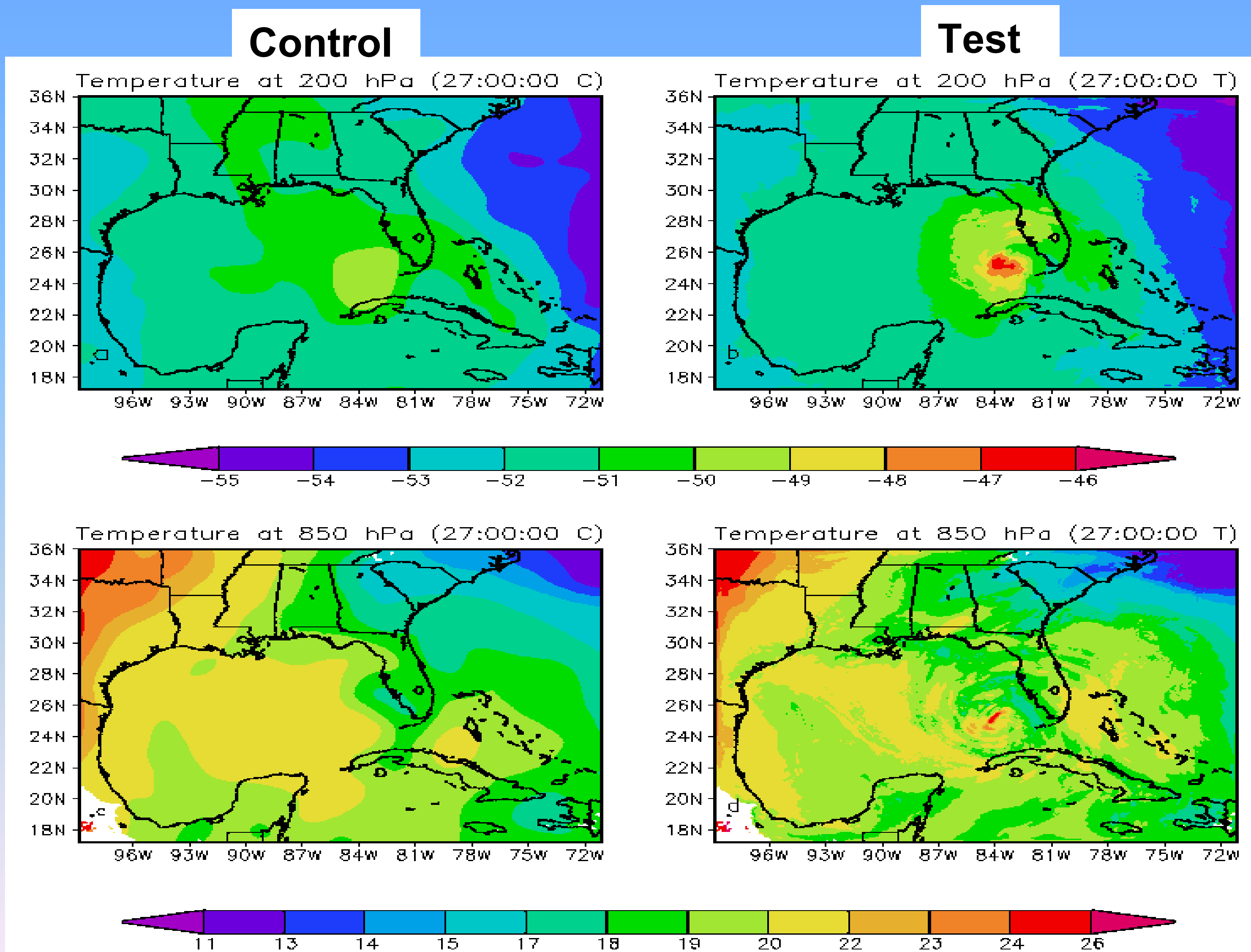
10hPa

100hPa

500hPa

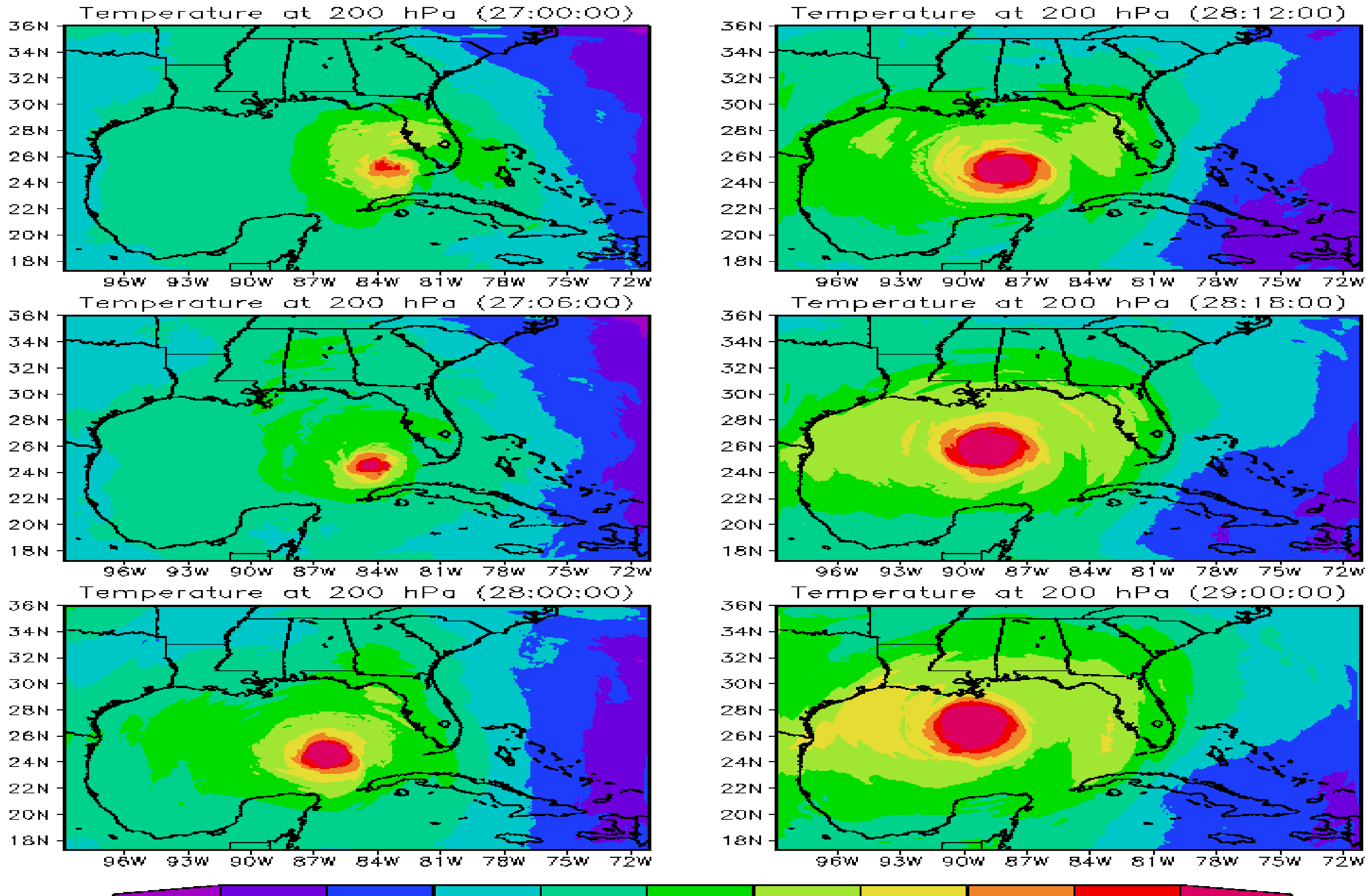
1000hPa

Impacts of SSMIS LAS on Hurricane Temperature Analysis



Liu and Weng, GRL, 2007

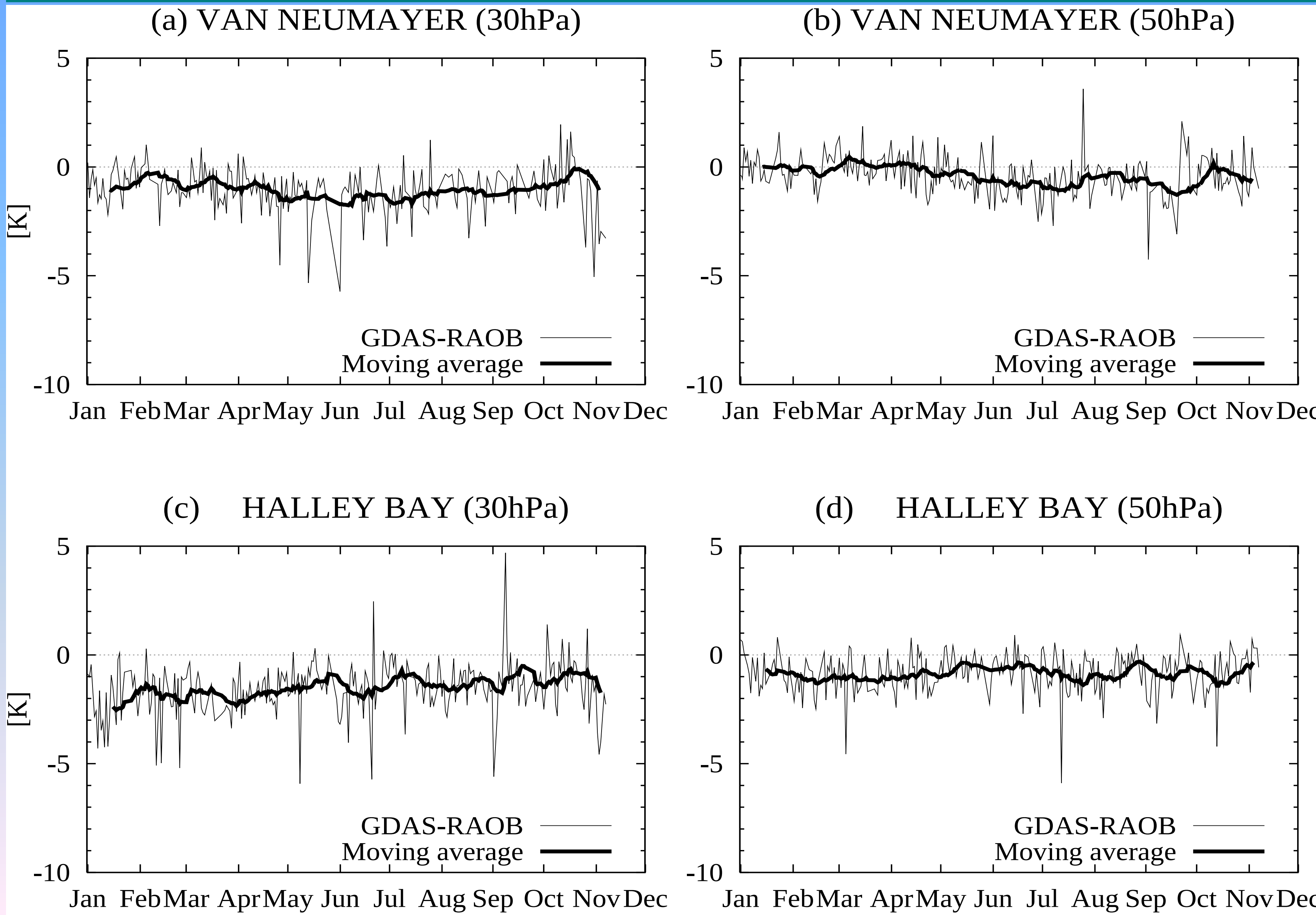
Katrina Warm Core Evolution



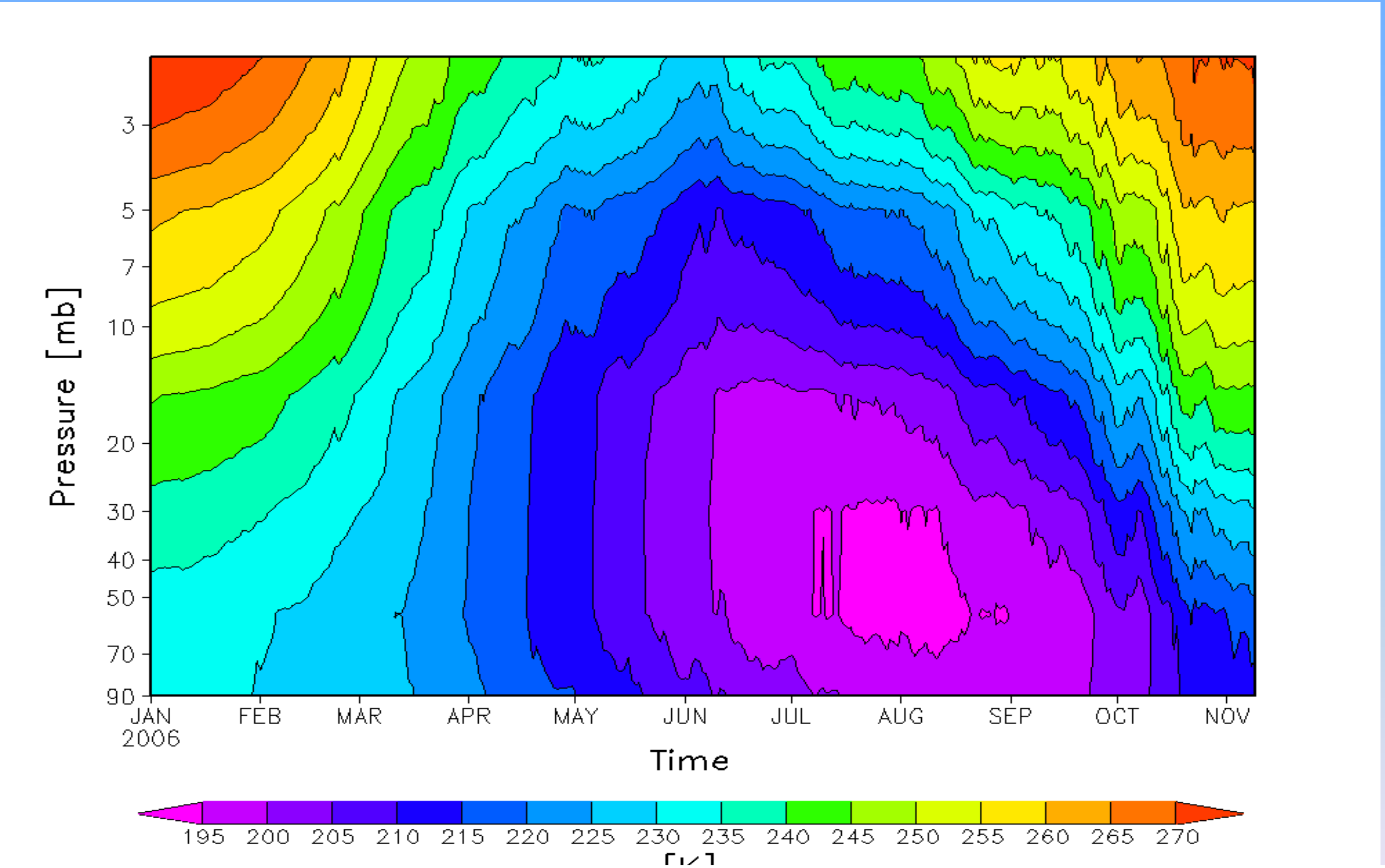
Impacts from SSMIS UAS Data on Global Upper-Air Analysis

- **Innovation vectors are computed from**
  - Global Forecast System (GFS) 6 hour forecasts
  - GSI with SSMIS Channels 5,6,7, 22, 23, 24

GDAS Biases in Stratosphere

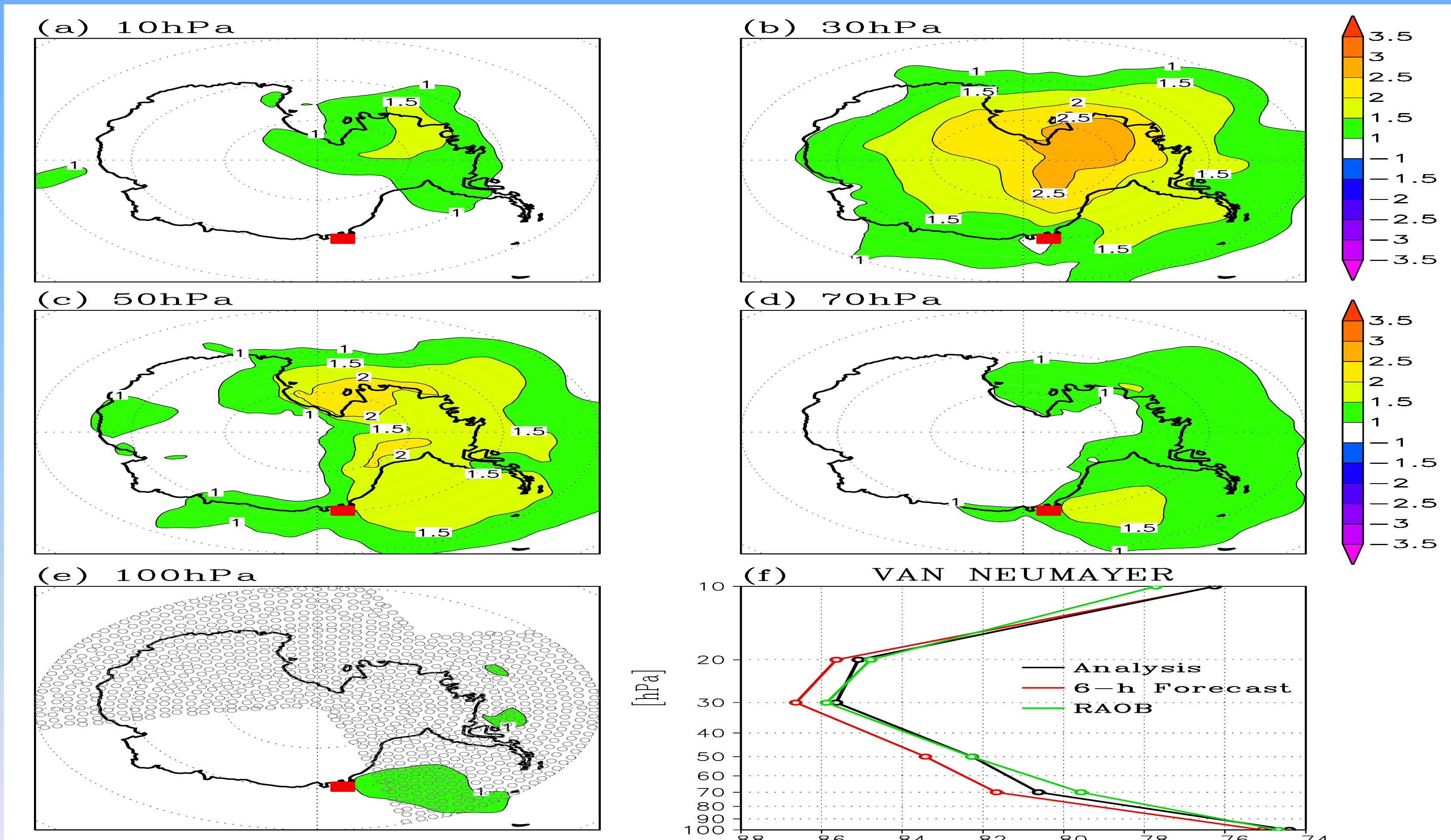


SSMIS Interpolated to Various Pressure Levels



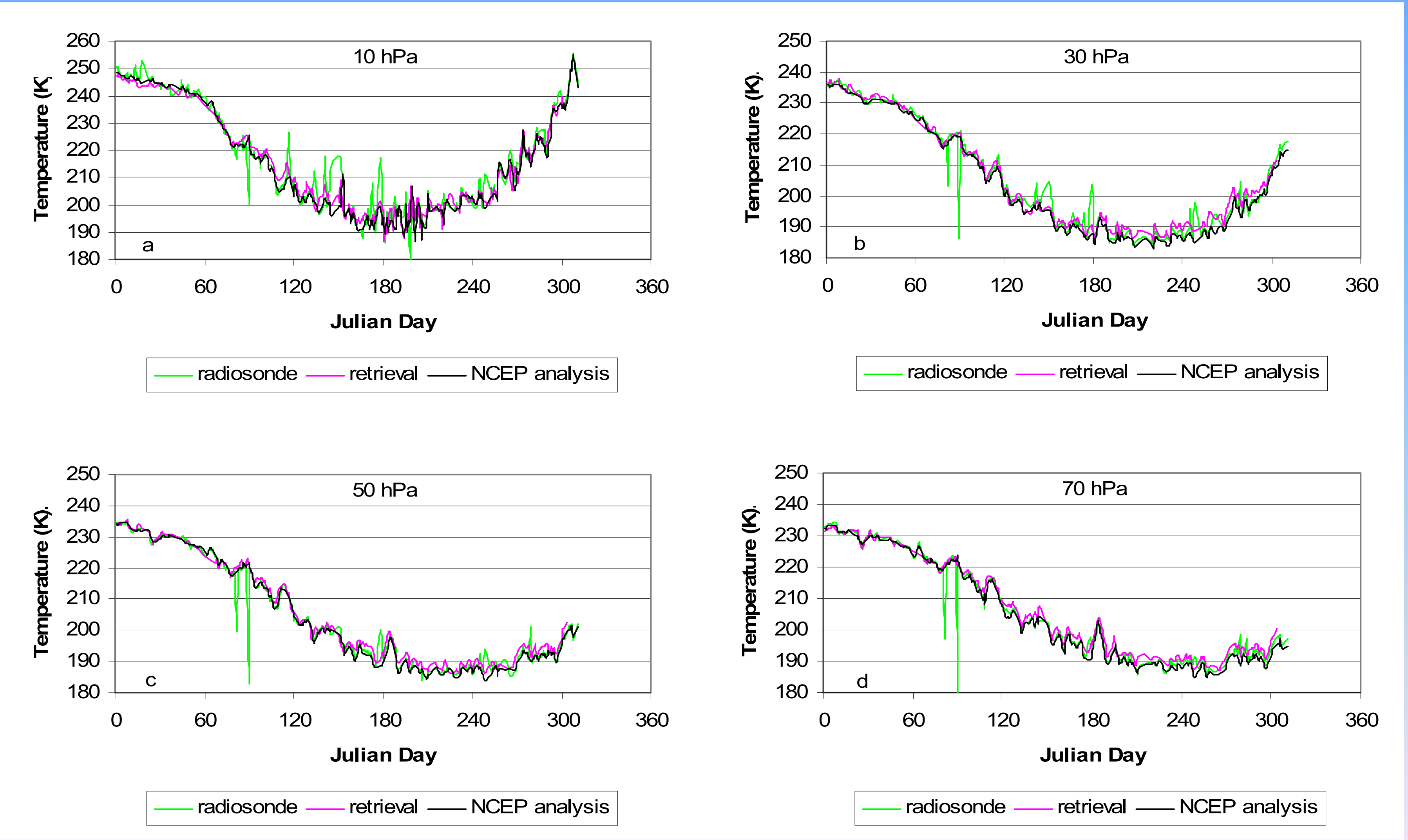
A snapshot of a time series of the interpolated brightness temperatures at SSMIS channels 22, 23, 24, 7, 6, and 5 averaged over 60º South and South Pole for 2006.

SSMIS UAS Innovations to GFS 6 Hour Forecasts



Differences of stratospheric temperatures between new analyses and 6-hour forecast for 12 UTC June 29, 2006. The red colored square indicates the Van Neumayer station. The black circles are footprints of the SSMIS measurements. The stratospheric temperature profiles from 6-hour forecast, radiosonde, and new analysis for the time are given in (f).

GDAS Analysis vs. SSMIS Retrievals, Roabs



Comparisons of times series of the stratospheric temperatures in 2006 at Van Neumayer station. The Green, red, and black lines represent radiosondes, retrievals using real SSMIS measurements, and NCEP

JCSDA WindSat Testing

- Coriolis/WindSat data is being used to assess the utility of passive polarimetric microwave radiometry in the production of sea surface winds for NWP
- Study accelerates NPOESS preparation and provides a chance to enhance the current global system
- Uses NCEP GDAS

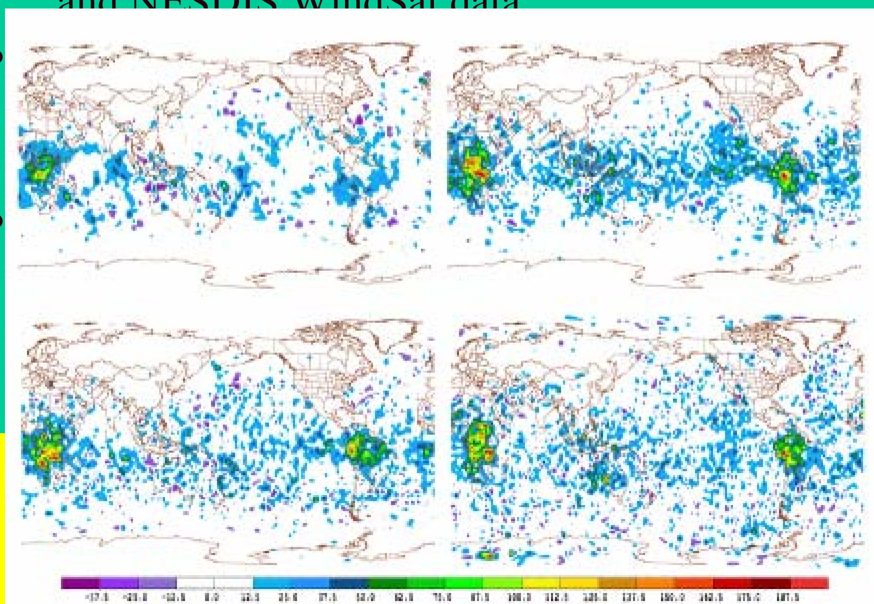
Bi Li and Mike Morgan, CIMSS

Assimilation of WindSat Data in the GFS

Contributors: Li Bi, Tom Zapotocny, Jim Jung (CIMSS) and Michael Morgan

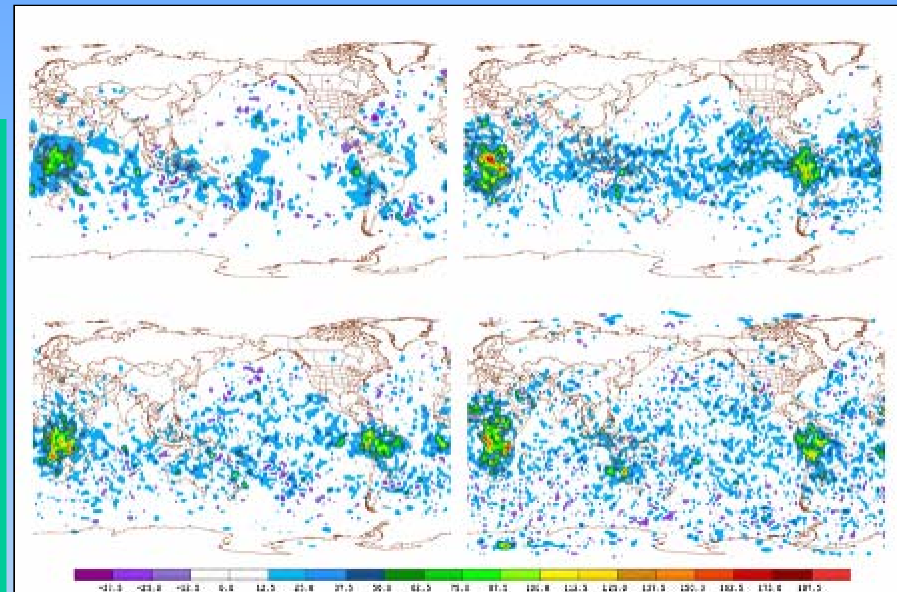
Summary of Accomplishments

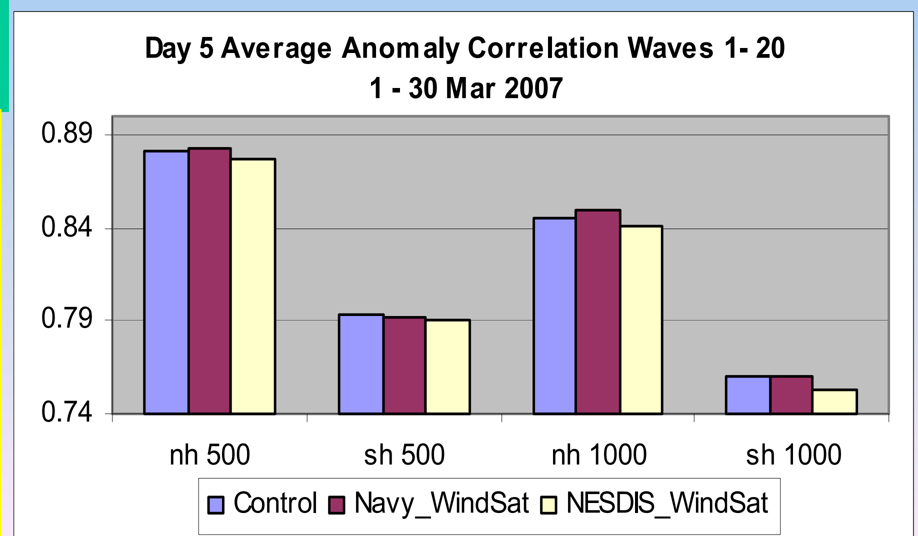
- Developed preliminary quality control for Navy and NESDIS WindSat data



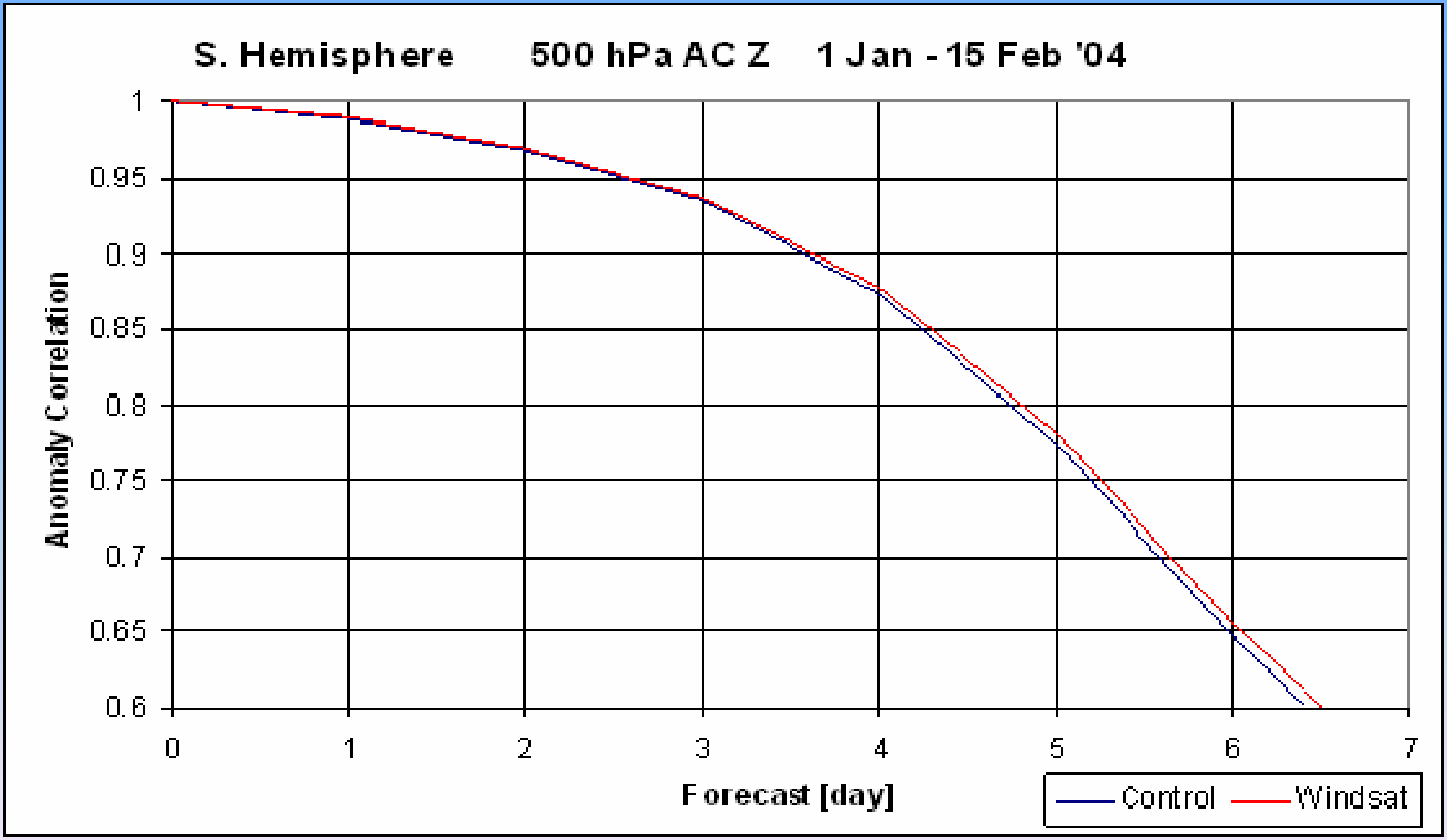
- Develop the direct assimilation of the WindSat radiances into the GFS and compare results obtained from Navy/NESDIS WindSat retrieval.

925 hPa FCST IMPACT 24-HR NAVY WINDSAT MARCH 1 – MARCH 30 2007





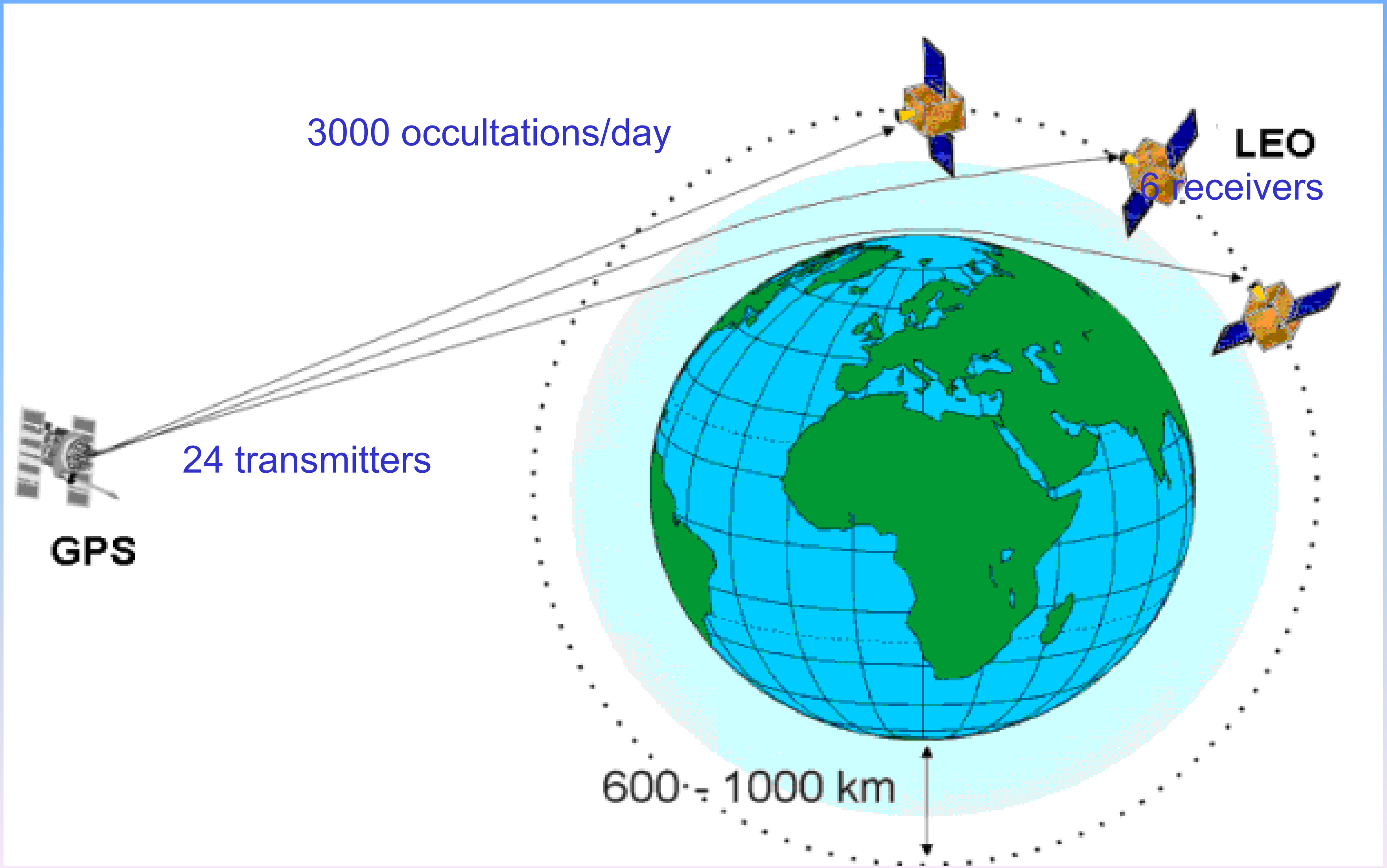
WindSat v Ops - QuikSCAT



Assimilation of GPS RO observations at JCSDA

Lidia Cucurull, John Derber,
Russ Treadon, Jim Yoe…

GPS RO / COSMIC



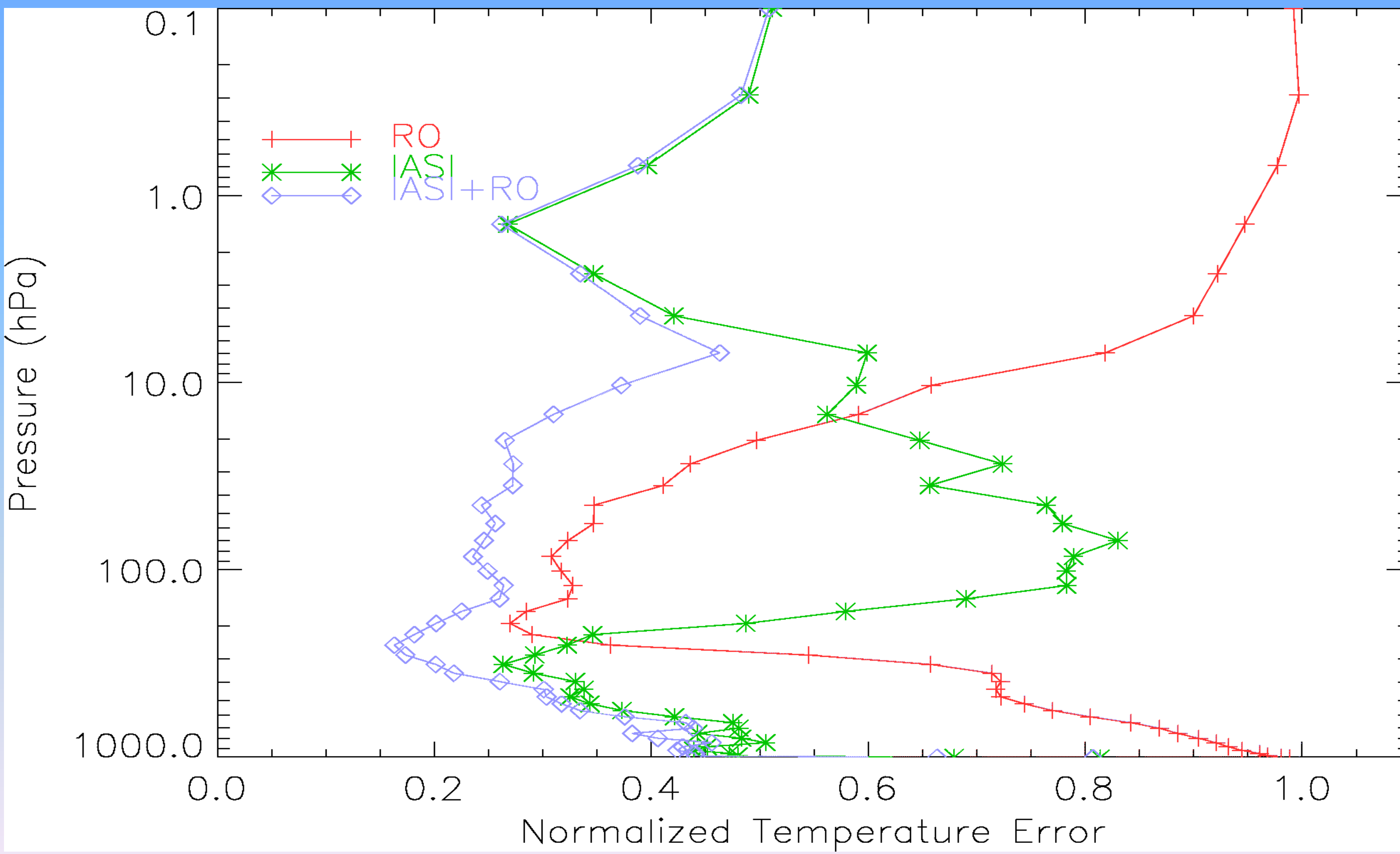
GPS RO /COSMIC:

- **COSMIC: The COnstellation of Satellites for Meteorology, Ionosphere, and Climate**
- **A Multinational Program**
  - Taiwan and the United States of America
- **A Multi-agency Effort**
  - NSPO (Taiwan), NSF, UCAR,
  - NOAA, NASA, USAF
- **Based on the GPS Radio Occultation Method**

GPS RO / COSMIC :

- **Goals are to provide:**
  - Limb soundings with high vertical resolution
  - All-weather operating capability
  - Measurements of Doppler delay based on temperature and humidity variations, convertible to bending angle, refractivity, and higher order products (i.e., temperature/humidity)
  - Suitable for direct assimilation in NWP models
  - Self-calibrated soundings at low cost for climate benchmark

Information content from1D-Var studies IASI (Infrared Atmospheric Sounding Interferometer) RO (Radio Occultation) - METOP



(Collard & Healy, QJRMS,2003)

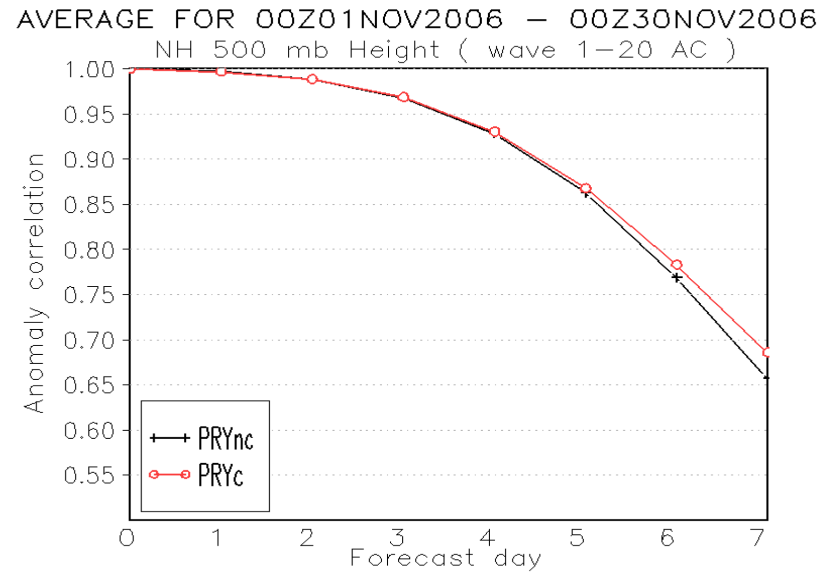
GPS RO / COSMIC (cont'd):

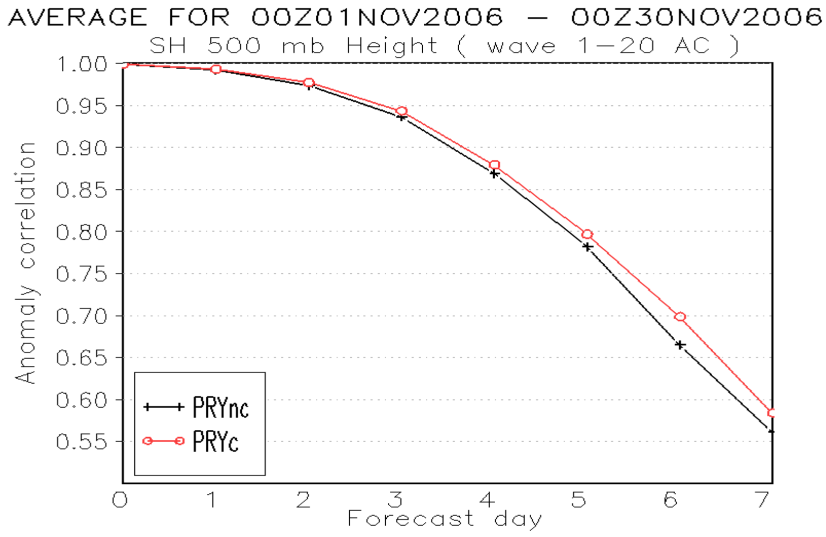
- COSMIC launched April 2006
- Lifetime 5 years
- Operations funded through March 08

COSMIC data was assimilated operationally

GSI/GFS Impact study with COSMIC

- **Anomaly correlation as a function of forecast day for two different experiments:**
  - PRYnc (assimilation of operational obs),
  - PRYc (PRYnc + COSMIC refractivity)
- **We assimilated around 1,000 COSMIC profiles per day**
- **In general, the impact of the COSMIC data will depend on the meteorological situation, model performance, location of the observations, etc.**





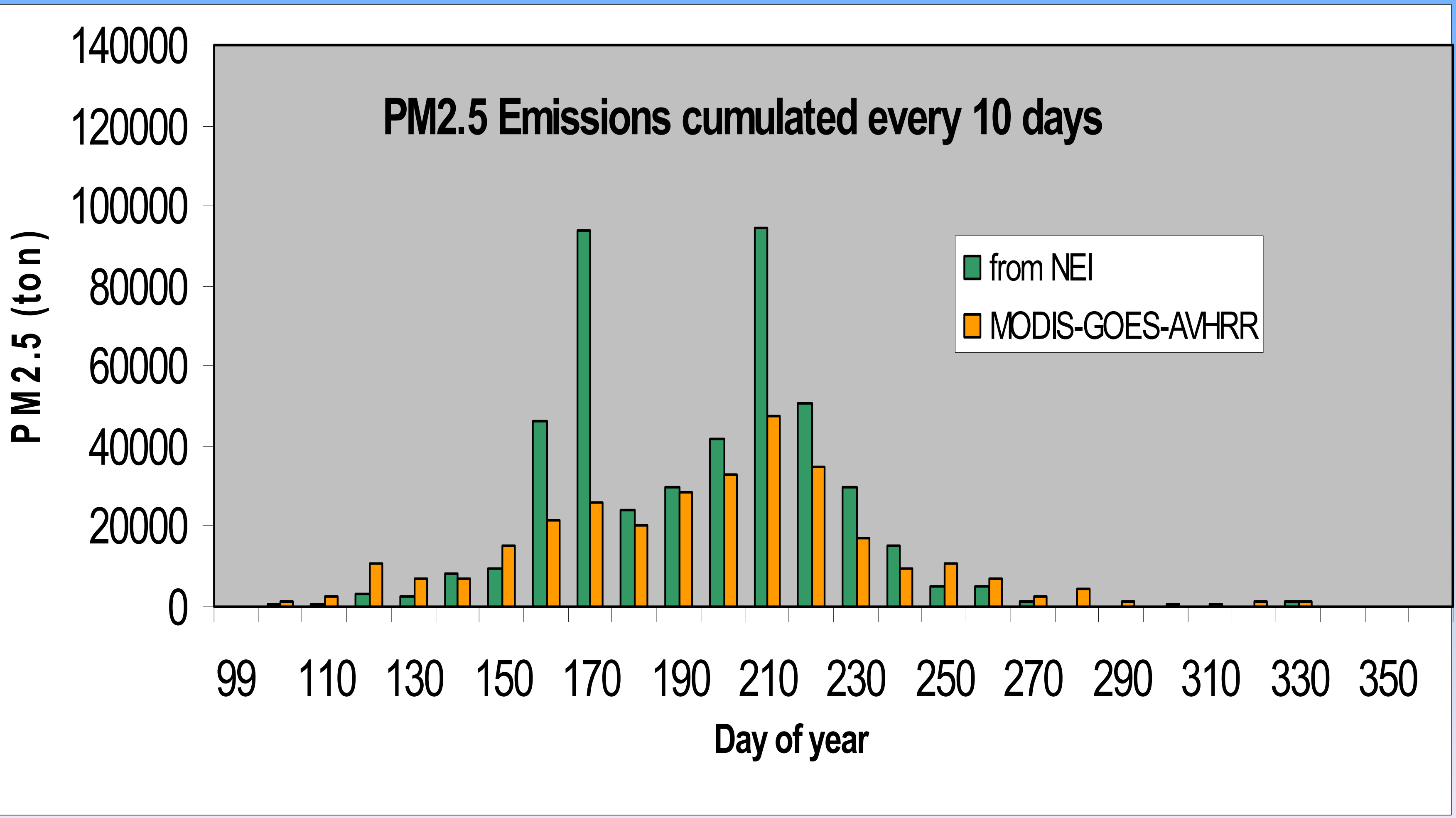
Assimilating satellite observations for Air quality forecasts

S. Kondragunta, X Xhang, Q Zhao, G. Pouliot, R. Mathur, T. . Pierce, J McQueen, P. Lee, L. Flynn, T. Beck, M. Liu, S. Lu

Air Quality Modeling/Product Development Projects

- Assimilation of satellite derived biomass burning and PM2.5 emission in CMAQ
- OMI NRT Processing for CPC
- GOME2 NRT Processing and Product Improvements
- Including Aerosol Scattering and Emission in CRTM

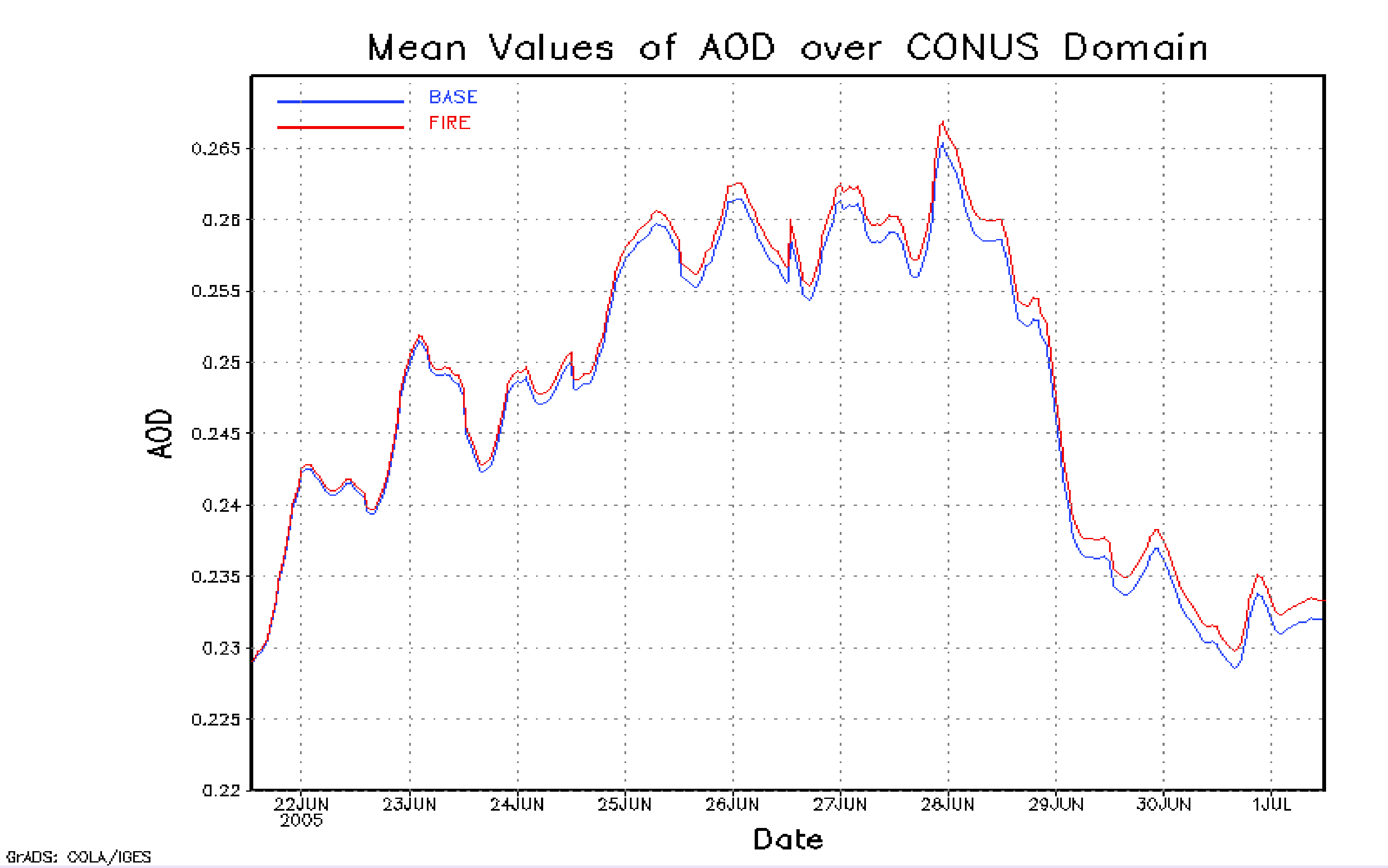
Verification of Satellite-based Biomass Burning PM2.5 Emissions



Assimilation Run

- AQF-aerosol version of CMAQ for the CONUS for June 2005
- Model grid was 12 km X 12 km
- Carbon-bond 4 chemistry
- 24-hour cycling period. Hourly forecasts for 48 hours beginning at 12Z
- Assumed emissions for a 24-hour time period persisted for the next 48 hours

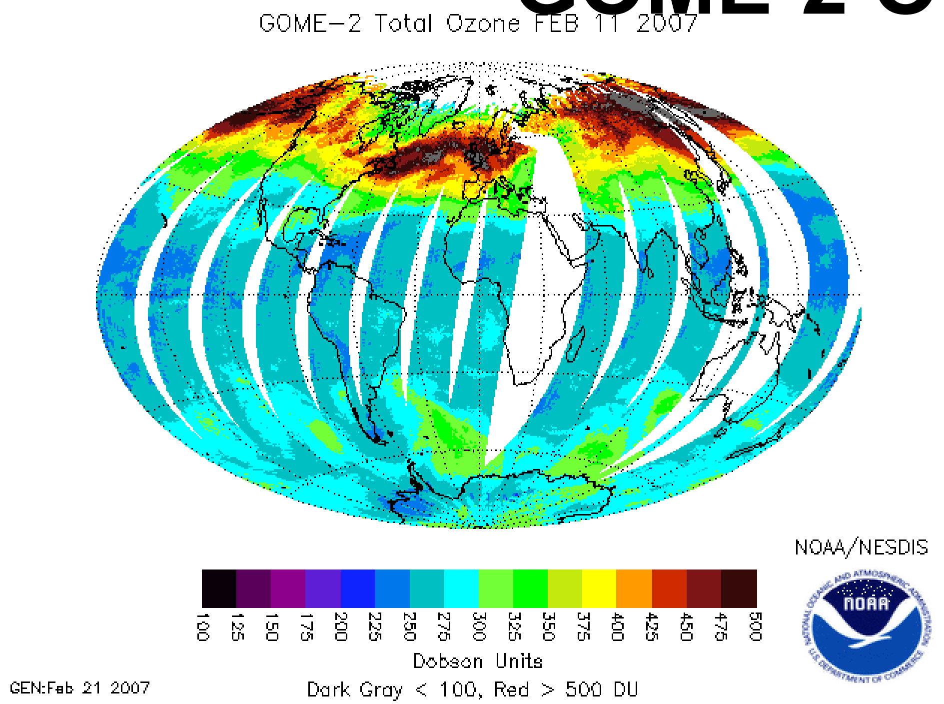
Time Series of Mean AOD

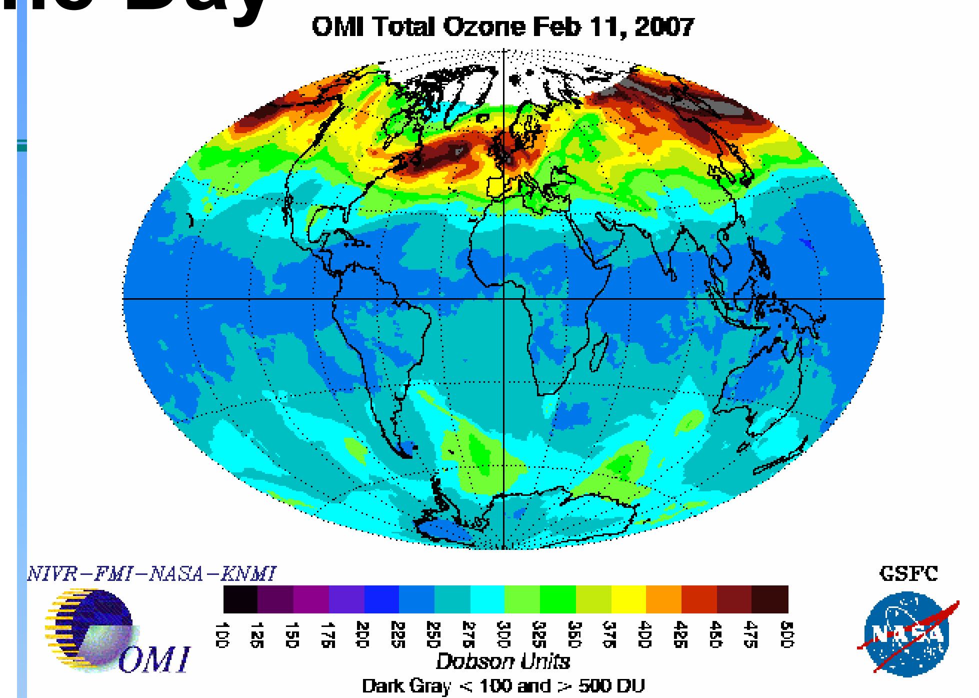


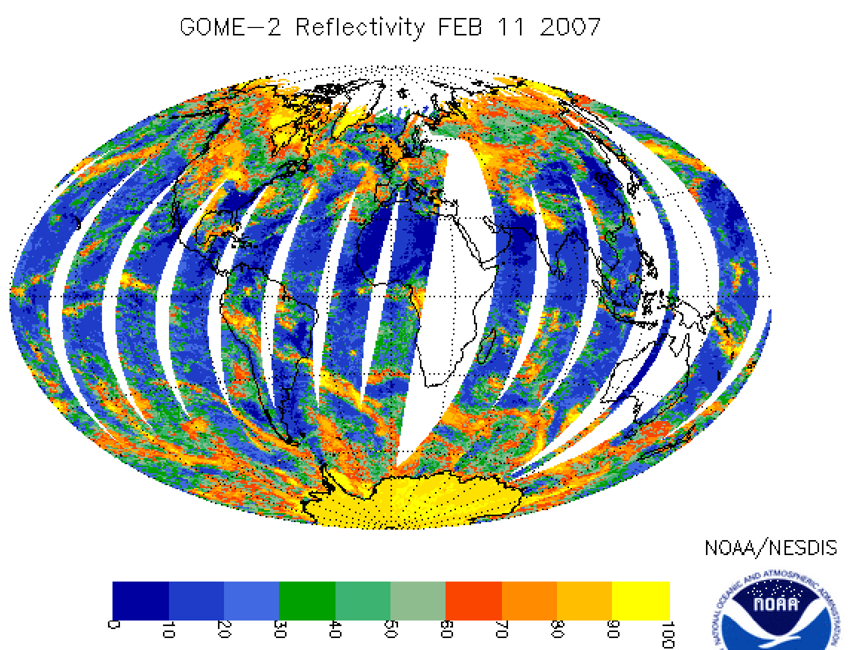
Initial Evaluation of GOME-2

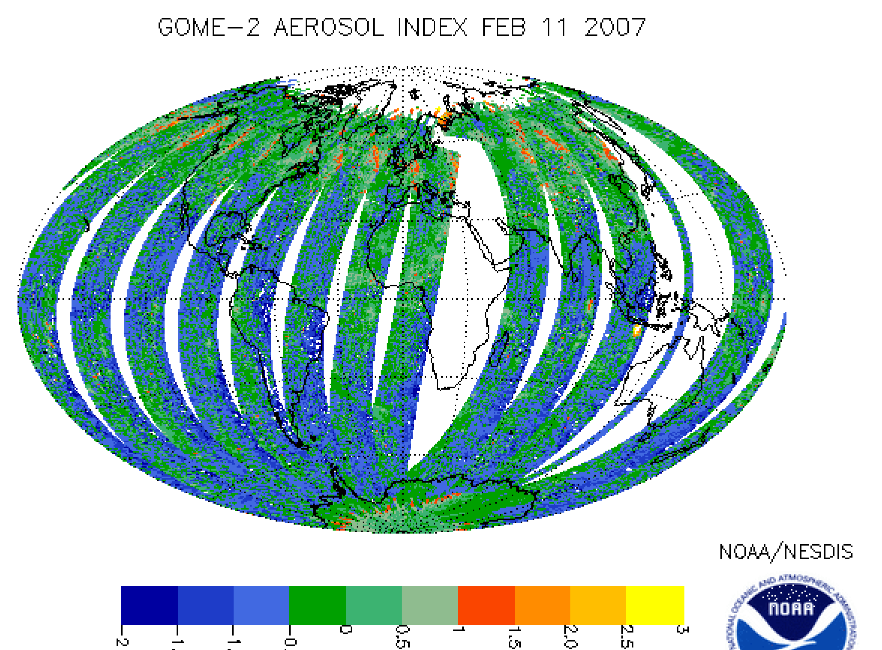
- **V8 and DOAS TOZ Algorithms are providing comparable products**
  - Minor check of SZA needed
- **V8 GOME-2 TOZ products have been compared to OMI and SBUV/2**
  - Reflectivity values are ~5% high for GOME-2
    - From comparisons of Max/Min and Ice reflectivity
  - B-pair TOZ is ~3% high
  - A-pair TOZ is poorly calibrated and D-Pair TOZ has other problems
  - SO2 channels have drifts and shifts during orbits; possibly related to polarization corrections or Band 1B/Band 2B calibration offsets
  - Aerosol Index has slight offset but proper variation and wavelength dependence at 345, 360, and 372 nm
  - Initial recommendation:
    - Compute and implement adjustment to reflectivity, aerosol Index, and B-pair channels
    - Use Step 1 TOZ and screen for Aerosol Index.
- **V8 GOME-2 Ozone Profile products are under investigation**
  - Averaging to produce broad channels reduces noise
  - Possible discretization problem observed
- **DOAS trace gas products are on track**
  - Good SNR for spectral windows for NO2 DOAS retrievals.

GOME-2 One Day









Assimilation of Satellite Observations over Land

Le Jiang, Dan Tarpley, Wei Guo, Felix Kogan, and Kenneth Mitchell

AVHRR-Based Global Vegetation Processing System (GVPS)

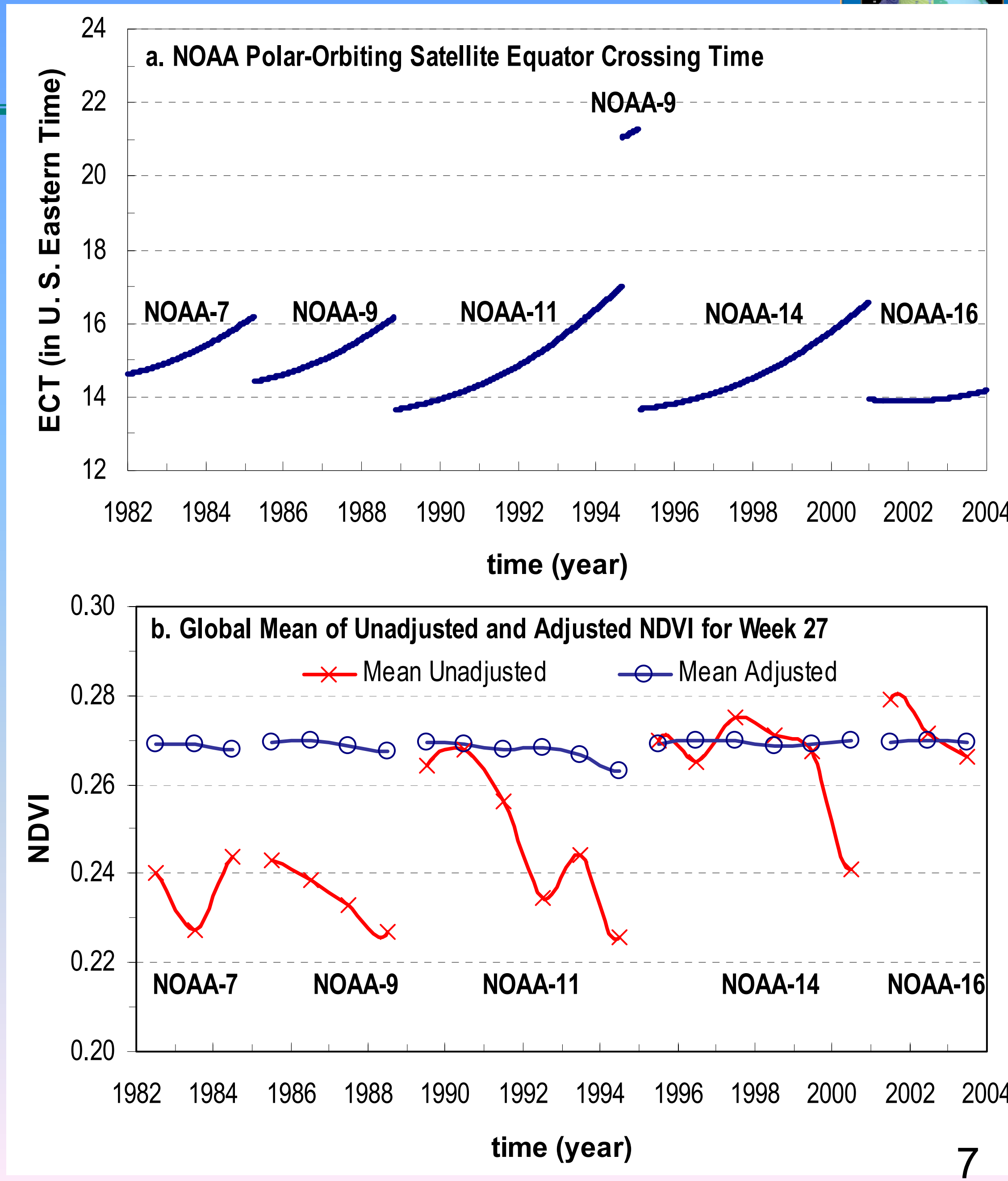
- Implementing the adjusted cumulative distribution function (ACDF) method in operational NDVI algorithm to correct the satellite orbital drift

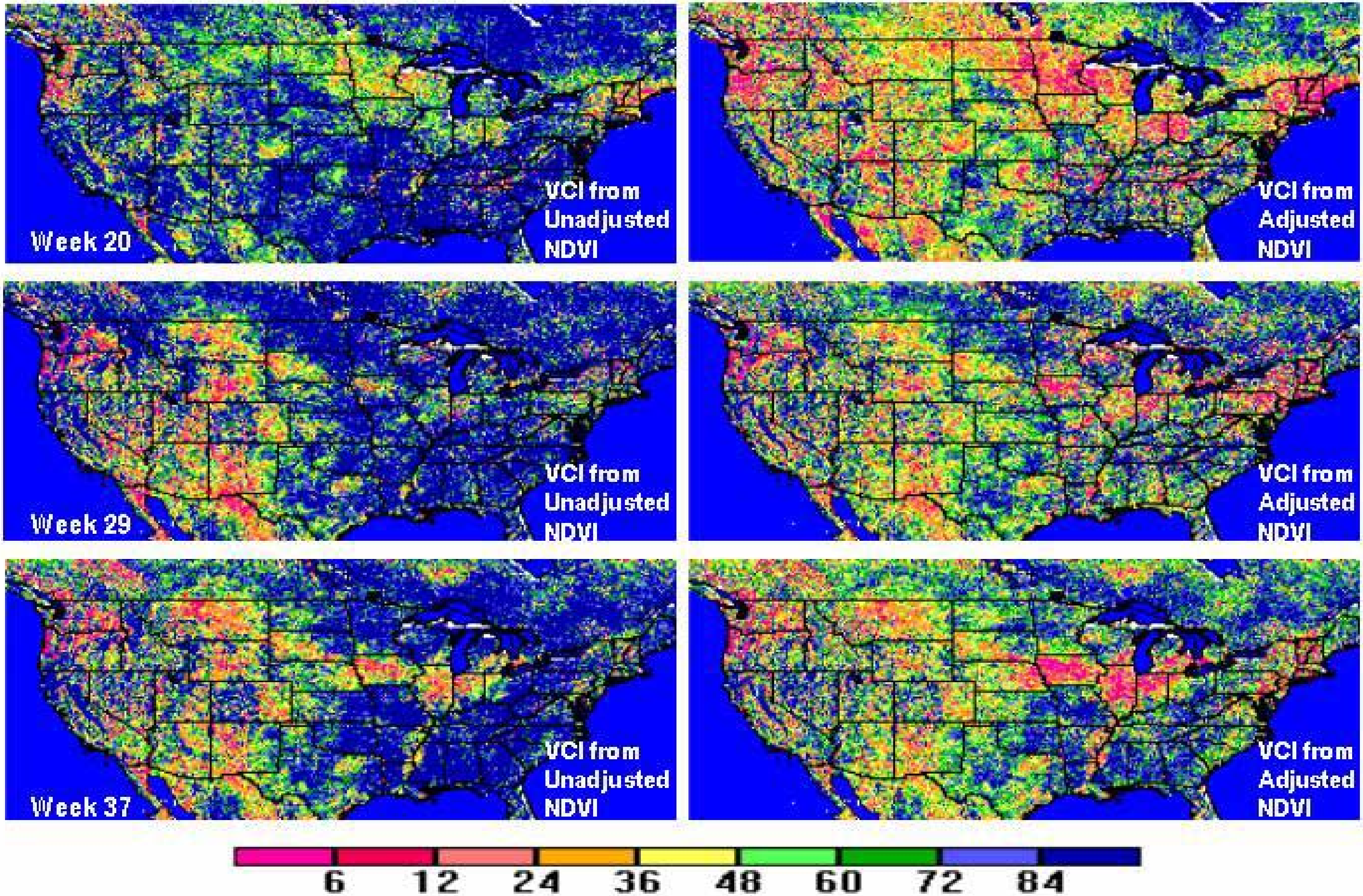
- Producing a consistent and quality improved long-term NDVI dataset

- Operational data availability to NCEP/EMC (expected by June 2007)

Satellite ECTs for the period 1982 to 2003

Global mean of unadjusted and adjusted NDVI for week 27 from 1982 to 2993.





Comparison of Vegetation Condition Index (VCI) resulted from un-adjusted and adjusted NDVI datasets over the CONUS (27N~53N, 127W~67W) in 2005 for weeks 20 (May), 29 (July) and 37 (September)

Assimilation of Satellite Observations over Oceans

Paul Change, Banghua Yan, Fuzhong Weng, Nick. Nalli

STAR Ocean Projects Supporting JCSDA

- Prepare Quikscat and Windsat ocean wind vectors for assimilation testing
- Fast ocean polarimetric emissivity and sea ice emissivity model
- improve water-leaving radiance calculation through uses of MOREL bi-optical model and directly coupled RT schemes
- GOES SST products
- Beginning a planning of ocean data assimilation program through NOAA IOOS initiative

NESDIS/STAR Publications (2006-2007) Supported through JCSDA

LeMarshall, J, et al., the Joint Center for Satellite Data Assimilation, Bull Amer Meteor, Soc, pp 329-240.

Zapotocny et al., 2007, A Two Season Impact Study of Four Satellite Data Types and Rawinsonde Data in the NCEP Global Data Assimilation System, WAF, (revised)

Jiang, L., J. D. Tarpley, K. E. Mitchell, W. Guo, B. H. Ramsay, and F. N. Kogan, Deriving near real time global green vegetation fraction from AVHRR-based global vegetation indices, to be submitted to JHM, 2007.

Jiang, L., J. D. Tarpley, K. E. Mitchell, S. Zhou, F. N. Kogan, and W. Guo, Adjusting for long term anomalous trends in NOAA's global vegetation index datasets, in review at IEEE Trans. Geosci. Rem. Sens., 2007.

Liu, Q. and F. Weng, 2006: Advanced doubling–adding method for radiative transfer in planetary atmospheres, J. Atmos. Sci., 63, 3459-3465,

Weng, F., T. Zhu, and B. Yang, 2007: Satellite data assimilation in numerical weather prediction models, 2. Uses of rain affected microwave radiances for hurricane vortex analysis, J. Atmos. Sci., (in press).

Weng, F., 2007: Advances in radiative transfer modeling in support of satellite data assimilation, J. Atmos. Sci., (in press).

Han, Y, F. Weng, Q. Liu, and P. van Delst, 2007: A fast radiative transfer model for SSMIS upper-atmosphere sounding channels, J. Geophys. Res, (accepted)

Liu, Q. and F. Weng, 2006, Combined Henyey–Greenstein and Rayleigh phase function, Appl. Opt., 45, 7475-7479

Kondragunta, S., P. Lee, J. McQueen, C. Kittaka, P. Ciren, A. Prados, I. Laszlo, B. Pierce, R. Hoff, J. J. Szykman, Air Quality Forecast Verification using Satellite Data, Journal of Applied Meteorology and Climatology, accepted, 2007

JAS Special volume on assimilation of cloud and precipitation data from satellites

IEEE Special volume on surface remote sensing and property modeling

Concluding Remarks

NESDIS/STAR has provided to JCSDA strong supports in resource, management and science leadership

Challenges in Satellite Data Assimilation

- Difficult to ingest all hyperspectral sounding data when more trace gases are included
- Difficult to use satellite measurements that are affected by surface
- Difficult to assimilate satellite radiances that are affected by aerosols and clouds
- New initiatives in ocean data assimilation